What is claimed is:

1. An optical amplification element for amplifying light, the optical amplification element comprising:

a semiconductor quantum well structure having a quantum well active region whose effective bandgap properties are modified such that the semiconductor quantum well structure functions as an optical amplifier with a gain spectrum; and

an electrode for applying a current to the semiconductor quantum well structure to control the gain spectrum.

2. The optical amplification element of claim 1, comprising:

a plurality of quantum well active regions in said semiconductor quantum well structure, each having a different gain spectrum; and

a plurality of said electrodes, one for each of said plurality of said quantum well active regions.

3. The optical amplification element of claim 2, wherein the plurality of said quantum well active regions have different compositions.

4. The optical amplification element of claim 1, wherein the quantum well active region is an indium gallium arsenide phosphide (InGaAsP) quantum well active region.

5. A wavelength converter for modulating a first light beam having a first wavelength in accordance with data carried in a second light beam having a second wavelength to output a third light beam having the first wavelength and carrying the data, the wavelength converter comprising:

an interferometer, having a gate, for receiving the first and second light beams and for causing the first and second light beams to interfere in the gate to modulate the first light beam in accordance with the data carried in the second light beam; and

an optical amplifier disposed in the gate, the amplifier being controllable to vary a gain spectrum of the amplifier for different values of the first wavelength, the amplifier comprising:

a semiconductor quantum well structure having a quantum well active region whose effective bandgap properties are modified such that the semiconductor quantum well structure functions as the optical amplifier with the gain spectrum; and

an electrode for applying a current to the semiconductor quantum well structure to control the gain spectrum.

6. The wavelength converter of claim 5, wherein the quantum well active region is an indium gallium arsenide phosphide (InGaAsP) quantum well active region.

7. A method of making an optical amplification element for amplifying light, the method comprising:

(a) forming, in a semiconductor quantum well structure, a quantum well active region;

(b) modifying effective bandgap properties in the quantum well active region so that the effective bandgap properties cause the quantum well active region to function as an optical amplifier with a gain spectrum; and

providing an electrode in electrical communication with the quantum well active region.

8. The method of claim 7, wherein:

step (a) comprises providing a plurality of said quantum well active regions in said semiconductor quantum well structure;

step (b) comprises modifying the effective bandgap properties of each of the quantum well active regions such that the quantum well active regions have different gain spectra; and

step (c) comprises providing a plurality of said electrodes, each in electrical communication with one of said plurality of quantum well active regions.

9. The method of claim 8, wherein step (b) comprises modifying the bandgap properties by spatially varying a spatial variation in a composition of the quantum well active region.

10. The method of claim 8, wherein step (b) comprises modifying the bandgap properties by spatially varying a thickness of the quantum well active region.

11. The method of claim 8, wherein the plurality of wavelengths comprises wavelengths in a range from 1.3 μm to 1.6 μm.

12. The method of claim 8, wherein the quantum well active region is an indium gallium arsenide phosphide (InGaAsP) quantum well active region.

13. The method of claim 12, wherein step (b) comprises rapid thermal annealing for controlled diffusion of defects into the quantum well active region.

14. The method of claim 13, wherein step (b) comprises:

(i) on top of the semiconductor quantum well structure, providing a first indium phosphide (InP) layer with vacancy type defects, wherein the vacancy type defects act as slow diffusers;

(ii) on top of the first InP layer, providing a second InP layer with interstitial type defects, wherein the interstitial type defects act as fast diffusers; and

(iii) applying a rapid thermal annealing process to the semiconductor quantum well structure for controlled diffusion of the vacancy type defects and the interstitial type defects into the quantum well active region.

15. The method of claim 13, wherein step (b) comprises:

(i) on top of the semiconductor quantum well structure, providing an indium phosphide (InP) layer with point defects, wherein the point defects are donor-like phosphorus antisites or acceptor-like indium vacancies; and

(ii) applying a rapid thermal annealing process for controlled diffusion of the point defects into the quantum well active region.

16. A method of amplifying light having at least one wavelength, the method comprising:

(a) passing the light through a semiconductor quantum well structure having a quantum well active region whose effective bandgap properties are modified such that the semiconductor quantum well structure functions as an optical amplifier with a gain spectrum; and

(b) applying a current to the semiconductor quantum well structure to control the gain spectrum.

17. The method of claim 16, wherein:

step (a) comprises passing the light through a plurality of said quantum well active regions in said semidconductor quantum well structure, each of said quantum well active regions having a different gain spectrum; and

step (b) comprises applying a separate current to each of the semiconductor quantum well structures to control the gain spectrum of said each of the quantum well active regions, thereby achieving a total gain spectrum.

18. The method of claim 17, further comprising (c) making a determination of whether the total gain spectrum is adequate for an intensity spectrum of the light, and wherein step (b) comprises controlling values of the separate currents in accordance with the determination made in step (c) to control the total gain spectrum.

19. The method of claim 16, wherein the quantum well active region is an indium gallium arsenide phosphide (InGaAsP) quantum well active region.

20. A method of modulating a first light beam having a first wavelength in accordance with data carried in a second light beam having a second wavelength to output a third light beam having the first wavelength and carrying the data, the method comprising:

(a) providing an interferometer, having a gate, for receiving the first and second light beams and for causing the first and second light beams to interfere in the gate to modulate the first light beam in accordance with the data carried in the second light beam;

(b) providing an optical amplifier disposed in the gate, the amplifier being controllable to vary a gain spectrum of the amplifier for different values of the first wavelength, the amplifier comprising:

a semiconductor quantum well structure having a quantum well active region whose effective bandgap properties are modified such that the semiconductor quantum well structure functions as the optical amplifier with the gain spectrum; and

an electrode for applying a current to the semiconductor quantum well structure to control the gain spectrum; and

(c) injecting the first and second light beams into the interferometer such that the first light beam is modulated in the gate in accordance with the data carried in the second light beam, and wherein the first light beam is amplified in the optical amplifier.

21. The method of claim 20, wherein the interferometer is a Mach-Zehnder interferometer.

22. The method of claim 20, further comprising (d) controlling the current in accordance with an intensity spectrum of the first light to provide broadband modulation of the first light.

23. The method of claim 20, wherein the quantum well active region is an indium gallium arsenide phosphide (InGaAsP) quantum well active region.